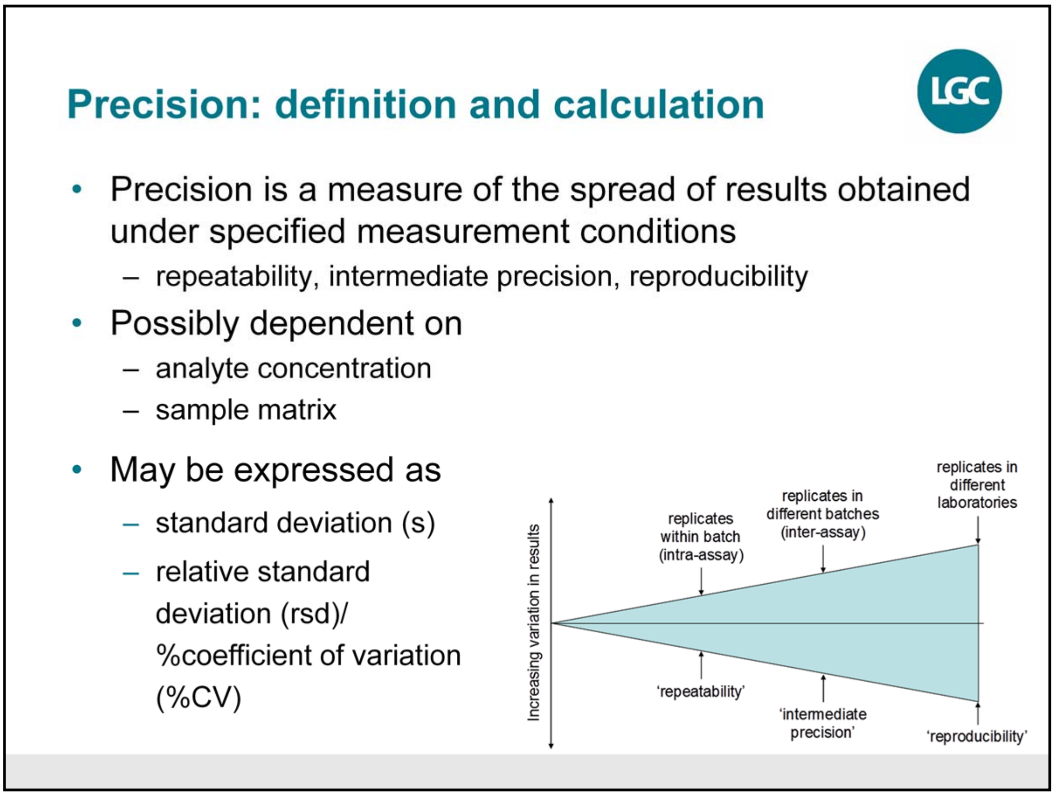
Including precision in an uncertainty estimate

Overview

- Definition and calculation of precision
- Different types of precision estimate
- Measurement uncertainty and precision studies
- Forms of precision data
- Contribution of precision to overall uncertainty



It is important to note are that when evaluating precision test results need to be independent, and that precision is defined for stated conditions (explanation about the stated conditions are in the next slide).

Precision determinations start with replicate analyses made within a given set of conditions. The simplest form of expression is to state the standard deviation (s) so obtained. Assuming normal distribution, 95% of values should lie within $\pm 2s$ of the mean.

Dividing the standard deviation by the mean value gives the relative standard deviation (rsd) (also known as the coefficient of variation (CV).

What varies?

	Repeatability	Intermediate precision	Reproducibility
Sample prep	●	●	◐
Extraction	●	●	●
Reagents	○	◐	●
Environment	○	◐	●
Equipment	○	◐	●
Operator	○	◐	●
Matrix effect	○	○	○

Different factors vary under different conditions. The table above shows some examples of factors and the conditions under which they typically vary.

Clearly, precision measured under each set of conditions gives different information. None is the 'right' precision; measurement uncertainty estimation can employ precision measures effectively for all or part of a procedure.

In general, a better idea of the full variability of a method under all conditions is obtained under reproducibility conditions. But even here, important factors may be missing. Collaborative studies usually use homogenised materials, reducing the effects of sample preparation, and reproducibility figures are almost invariably quoted for single matrices, neglecting systematic matrix effects.

Implication

If the precision experiments are properly done, there is less work to do in evaluating uncertainty

... but MAKE SURE OF WHAT IS VARIED!

Sources of data

- In-house method validation studies
  - ideally intermediate precision
- Ongoing in-house quality control
  - standard deviation of 'acceptable' QC results
- Published standard methods (used without modification)
  - reproducibility estimate from interlaboratory validation study
- Results from EQA
  - if participants' results can be grouped by test method

May need more than one estimate to cover the method scope

There are a number of sources of data that can provide an estimate of method precision for inclusion in an uncertainty estimate.

Data from a well-planned in-house validation study is an excellent source of data. An estimate of intermediate precision, obtained over several days using more than one analyst would be expected to cover the significant sources of random variability within a method.

For established methods, data from the analysis of QC materials is useful source of information. The dataset used for an uncertainty estimate should only include 'acceptable' QC results. An uncertainty is intended to reflect the variation in results when the method is operating satisfactorily and is under control (i.e. the effect of 'gross errors' (mistakes) is not included).

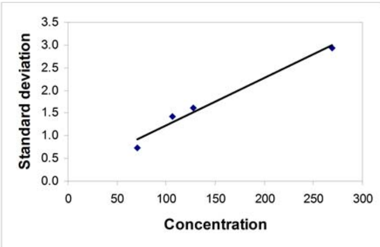
If a laboratory is using a standard published method that has been subject to validation via an interlaboratory study, then the estimate of reproducibly obtained from the study can be used as the precision component of the uncertainty estimate. This approach is described in detail in ISO 21748:2010 'Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation'.

In certain circumstances it may be possible to use data from rounds of an EQA scheme to obtain an estimate of precision. For example, if the same method is used by all the participants in the EQA round (or the data can be grouped by method), the standard deviation of results obtained by participants using the same method is equivalent to an estimate of interlaboratory reproducibility mentioned above.

Remember that the uncertainty study should cover a representative range of samples covered by the method scope. It may therefore be necessary to obtain more than one precision estimate and to pool the estimates to obtain a single value.

Dealing with precision data from several estimates

- Several estimates of precision may be required to cover method scope, i.e. concentration range or different matrices
- A single estimate could be more convenient but only possible when obtained estimates don't vary significantly
- Approximate methods:
  - regression: gradient gives RSD
    - insignificant intercept necessary for simple RSD
  - 'pooling'
    - easier to include 'weighting' for number of data points used (equation in notes)



It is common to find that several different estimates of standard deviation or relative standard deviation are available, and need to be combined to give a convenient single estimate of precision.

ISO 5725 (which describes how to estimate the Repeatability and Reproducibility of test methods) uses a simple regression approach to summarise such data. Where the intercept is negligible, fitting a line through the standard deviations plotted against mean analyte level gives the required rsd as the gradient of the line.

It is also possible, by analogy with pooled estimates of standard deviation, to calculate a 'pooled rsd'. This method takes better account of the number of data points in each estimate of standard deviation than does a simple unweighted linear regression. The equation for calculating a pooled rsd is:

$$\mathrm{rsd}_p = \sqrt{\frac{(n_1-1)\times\left(\frac{s_1}{\bar{x}_1}\right)^2 + (n_2-1)\times\left(\frac{s_2}{\bar{x}_2}\right)^2 + \ldots..}{(n_1-1)+(n_2-1)+\ldots..}}$$

Note that both methods are approximate. Strictly, using the means of a set of data to 'scale' the standard deviations (as both these methods do) introduces a bias in the calculated relative standard deviation. Nonetheless, both give reasonable results where the standard deviations are not large compared to the mean values. Using certified values to scale the data would not lead to estimates biased in this way, though other effects, such as recovery or analytical bias, would then introduce bias.

When the precision estimates vary significantly, it is not recommended to combine them using the methods describe above. Different estimations of uncertainty based on individual estimations of precisions may be required in this case.

Forms of precision data

- Standard deviation – useful where:
  - precision DOES NOT vary significantly with level of analyte etc
  - uncertainty estimate applies to a narrow range of analyte concentrations
- Relative standard deviation – useful where:
  - precision DOES vary with level of analyte etc
- Most common approach for chemical test methods
  - include precision term in uncertainty estimate as a relative value

Summary

- Precision is a measure of spread
- Use the best estimate of precision
  - usually the largest number
- Pool data if required and possible
- May need different estimates for different sample matrices, depending on method scope
- Generally include in uncertainty estimate as a relative value